Receipt PCT #2

08/973424

Docket No.: 392.1530

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re the Application of:

Nobuaki IEHISA, et al.

Serial No. 08/973,424 Group Art Unit: Unknown

Confirmation No. Unknown

Filed: December 8, 1997 Examiner: Unknown

For: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

PETITION REQUESTING U.S. PTO TO LOCATE FILE AND ISSUE FILING RECEIPT

Attention: Office of Petitions
Commissioner for Patents
PO Box 1450
Alexandria, VA 22313-1450

Sir:

As will be apparent from the Declaration of Applicant's counsel's manager of the docketing department, Mr. Victor Del Rio, the application was received by the U.S. Patent and Trademark Office on December 8, 1997 and assigned Serial Number 08/973,424. The date-stamped post cards are attached to Mr. Del Rio's Declaration, together with a complete copy of the application as filed.

On March 31, 1999 and November 18, 2002, Applicant submitted Information Disclosure Statements. Copies of the date-stamped postcards and Information Disclosure Statements are also enclosed.

Applicant filed a Status Inquiry Letter, copy attached, on June 13, 2000. Applicant filed a second Status Inquiry Letter on August 9, 2001 and the date-stamped postcard is attached. Applicant filed a third Status Inquiry Letter on November 6, 2002 and the date-stamped postcard is attached.

It is earnestly requested that Officials of the U.S. Patent and Trademark Office review this matter and determine the status of this application and thereafter issue an Official Filing Receipt.

Respectfully submitted,

STAAS & HALSEY LLP

Date: Aug 7, 2003

By: _____

James D. Halsey, Jr.
Registration No. 22,729

1201 New York Ave, N.W., Suite 700
Washington, D.C. 20005
Telephone: (202) 434-1500
Facsimile: (202) 434-1501

Docket No. 0392.1530

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of:

KARUBE, NORIO

Serial No.: 08/973,424 Group Art Unit:

Filed: December 8, 1997 Examiner:

For: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

DECLARATION OF VICTOR DEL RIO

Honorable Commissioner
of Patents & Trademarks
Washington, D. C. 20231

Sir:

I, **VICTOR DEL RIO**, declare that:

1. I have been employed in the Docketing Department of the firm of Staas & Halsey since July 21, 1997, and my title is Manager of Docketing Department.

2. I am directly responsible for docketing all incoming USPTO correspondence, and for making note of such correspondence and the due date for any response due, by the Docketing Department.

3. During the regular course of business, the USPTO mail received at Staas & Halsey is first opened and date-stamped, and separated into a specific file. The USPTO mail file is then passed directly to me in the Docketing Department. I check each piece of USPTO mail against our Docketing database by docket number and serial number. Any USPTO correspondence which requires a response is docketed in our Docketing database. Only then is the correspondence passed to the responsible attorney.

4. Attached hereto are copies of our Docketing database, for the above-identified application.

5. I further declare that all statements made herein of my knowledge are true, and all statements made herein on information and belief are believed to be true; and further that these statements have been made with the knowledge that willful false statements and the like so made punishable by fine or imprisonment, or both, under Section 1001 of

Title 18 of the United States Code, and that such willful false statement may jeopardize the validity of this application and any patent issuing hereon.

VICTOR DEL RIO
(Docketing Manager)

Date 8-6-03

8/6/2003 Patent Information Print

Docket No	0392-1530	Foreign Agent	
Country	United States	Oper Grp	
Case Type	Regular	Assignee No.3	
Relation Type	Original Filing	Assignee No.4	
Filing Type	National	Assignee No.5	
Filing Number		Techncl Editor	
Billing Attorney	Harry J. Staas	Client Ref No	FFA-1371
Original Atty	Harry J. Staas	Code #2	
Client\Division	AIWA INTERNATIONAL PATENT AG	Code #3	
Assignee No.1	FANUC LTD.	Code #4	
Assignee No.2		Code #5	
Client Refer. No.	FFA-1371	Code #6	
Status	Filed	Code #7	
Prio Filing Dt	4/8/1996	Code #8	
Sub Stat		Add Prio Appln No	
Sub Stat Dt		Add Prio Fil Dt	
Priority Country		Add Pri App No	
Parent Filing Dt	4/8/1996	Add Prio Fil Dtl	
Prior Appln No.	110556/1996	Assig 1 Reel/Frame	
Prio Issued Dt		Record Date 1	
Total Claims		Assig 2 Reel/Frame	
Ind. Claims		Record Date 2	
Serial #	08/973,424	Intrntl Class	
Filing Date	12/8/1997	U.S. Class	
Patent No		No. of Pages	
Issued Dt		Grp Art Unit	
Publication #		String	
Publication Dt		Verified	N
Entity Status		Customer	SNPP
Expiration Dt		Create Dt	6/24/1998
Conv Type		Update Dt	7/23/2003
Tax Base Dt		Update Tm	1514
Pat Proofing		Update User	VDR
Next Tax Dt		Update Type	

Actions

Action	Incoming Mail Recvd	Patent Proofer	
Act Due Date	11/12/2002	Last Resp Atty	
DeadLn Dt		Inst Recvd Date	
Comp Dt	11/13/2002		

Act Notes
LTR RE: COPIES OF A NOTICE OF GROUNDS FOR REJECTION**LM***

Action	IDS Filed	Patent Proofer	
Act Due Date	2/5/2003	Last Resp Atty	
DeadLn Dt		Inst Recvd Date	
Comp Dt	11/18/2002		

Act Notes
(13) IDS, FORM PTO-1449 & COPIES OF JP 06-268289, JP 07-099 358, JP 04-259275 AND ENG TRANS,
NO FEE ***

Action	Status Inquiry	Patent Proofer	
Act Due Date	10/6/2003	Last Resp Atty	
DeadLn Dt		Inst Recvd Date	
Comp Dt			

Act Notes
APPLN FILED 12/8/1997**

Action	Status Inquiry	Patent Proofer	
Act Due Date		Last Resp Atty	
DeadLn Dt		Inst Recvd Date	
Comp Dt	6/13/2000		

Action	IDS Filed	Patent Proofer	
Act Due Date		Last Resp Atty	
DeadLn Dt		Inst Recvd Date	
Comp Dt	3/31/1999		

Act Notes
tpo-1449, 2 refs., cpy of euro search rprt, no ck

Action	Communication Filed	Patent Proofer	
Act Due Date		Last Resp Atty	
DeadLn Dt		Inst Recvd Date	

Comp Dt 11/6/2002

Act Notes
(7) STATUS INQUIRY LTR, NO FEE **

Action Status Inquiry Patent Proofer
Act Due Date Last Resp Atty
DeadLn Dt Inst Recvd Date
Comp Dt 8/9/2001

Act Notes
SECOND STATUS INQUIRY***

Action IDS Not Applicable Patent Proofer
Act Due Date Last Resp Atty
DeadLn Dt Inst Recvd Date
Comp Dt

Action No Foreign Filing Needed Patent Proofer
Act Due Date Last Resp Atty
DeadLn Dt Inst Recvd Date
Comp Dt

Inventors

Inv Name KARUBE, NORIO Inv Cd 1
Assigned Inv Cd 2
Text #2 Real #1
Inventor Real #2
Inv Dt

Inv Name ET AL Inv Cd 1
Assigned Inv Cd 2
Text #2 Real #1
Inventor Real #2
Inv Dt

Title

Title
SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

Fax/Exprss Log

Trans Type Incoming Fax

Comments
5-26-00 1 PGS RE-ACKN/REPLY

Trans Type Express Mailed Recvd

Comments
11/13/2002 FED EX 8294 8955 3909 0409

Please return this card, indicating receipt date and Serial No., if applicable, of the following

PCT Appln. Transmittal, Verified Translation, PCT Request, Preliminary Amendment and check ($930)

Applicant(s): Nobuaki IEHISA, et al.

Title: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

Serial No.: To be assigned

Filing Date: December 8, 1997

Docket No.: 392.1530/JDH

Due Date: December 8, 1997

Please return this card, indicating receipt date and Serial No., if applicable, of the following

PCT Appln. Transmittal, Verified Translation, PCT Request, Preliminary Amendment and check ($930)

Applicant(s): Nobuaki IEHISA, et al.

Title: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

Serial No.: To be assigned

Filing Date: December 8, 1997

Docket No.: 392.1530/JDH

Due Date: December 8, 1997

08/973424

Rec'd PCT/PTO 08 DEC 1997

08/973424

Please Date Stamp and return

THIRD STATUS INQUIRY LETTER

[redacted] 11 AUG 2003

APPLICANT(S): Nobuaki IEHISA, et al.

SERIAL NO: 08/973,424

CONFIRMATION NO.

TITLE: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

FILING DATE: December 8, 1997

DOCKET NO: 392.1530/JDH:mbs

DUE DATE: N/A

(7)

Docket No.: 392.1530/JDH

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application:

Nobuaki IEHISA, et al.

Serial No.: 08/973,424 Group: Unassigned

Filed: December 8, 1997 Examiner: Unassigned

Title: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

THIRD
STATUS INQUIRY LETTER

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Applicant respectfully requests the status of the above-identified patent application, including an indication as to when the next communication can be expected.

Respectfully submitted,

STAAS & HALSEY LLP

Date: November 5, 2002 By: _____
James D. Halsey, Jr.
Registration No. 22,729

Suite 500
700 Eleventh Street, N.W.
Washington, D.C. 20001
Telephone: (202) 434-1500

Please Date Stamp and return

SECOND STATUS INQUIRY LETTER

APPLICANT(S):	Nobuaki IEHISA, et al.
SERIAL NO:	08/973,424
CONFIRMATION NO.	
TITLE:	SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE
FILING DATE:	December 8, 1997
DOCKET NO:	392.1530/JDH:mbs
DUE DATE:	N/A

(2)

08/973424

[illegible] 11 AUG 2003

Docket No.: 392.1530/JDH

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application:

Nobuaki IEHISA, et al.

Serial No.: 08/973,424 Group: Unassigned

Filed: December 8, 1997 Examiner: Unassigned

Title: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

SECOND
STATUS INQUIRY LETTER

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Applicant respectfully requests the status of the above-identified patent application, including an indication as to when the next communication can be expected.

Respectfully submitted,

STAAS & HALSEY LLP

Date: August 8, 2001

By: _____
James D. Halsey, Jr.
Registration No. 22,729

Suite 500
700 Eleventh Street, N.W.
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Telephone: (202) 434-1500

Please return this card, indicating receipt date and Serial No., if applicable, of the following

STATUS INQUIRY LETTER

Applicant(s):	Nobuaki IEHISA, et al.
Title:	SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE
Serial No.:	Unassigned
Filing Date:	December 8, 1997
Docket No.:	392.1530/JDH
Due Date:	

Docket No.: 392.1530/JDH

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application:

Nobuaki IEHISA, et al.

Serial No.: Unassigned Group: Unassigned

Filed: December 8, 1997 Examiner: Unassigned

Title: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

STATUS INQUIRY LETTER

Honorable Commissioner of
Patents and Trademarks
Washington, D.C. 20231

Sir:

Applicant respectfully requests the status of the above-identified patent application, including an indication as to when the next communication can be expected.

Respectfully submitted,

STAAS & HALSEY LLP

Date: June 12, 2000 By: _____

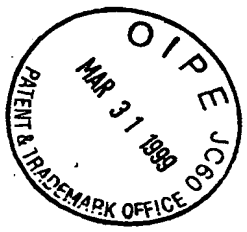
James D. Halsey, Jr.
Registration No. 22,729

700 Eleventh Street, N.W.
Washington, D.C. 20001
Telephone: (202) 434-1500

Please return this card, indicating receipt date and Serial No., if applicable, of the following

Information Disclosure Statement, Form PTO-1449, 2 refs., Copy of European Search Report, NO FEE

Applicant(s):	*Nobuaki IEHISA, et al.*
Title:	*SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE*
Serial No.:	*To be assigned*
Filing Date:	*December 8, 1997*
Docket No.:	*3921530/JDH*
Due Date:	---



(28)

Please Date Stamp and retu

IDS, Form PTO 1449 & Copies of [redacted]06-268289, JP 07-099358, JP 04-2592[redacted]nd English translation, NO FEE

APPLICANT(S): Nobuaki IEHISA, et al.

SERIAL NO: 08/973,424

CONFIRMATION NO.

TITLE: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

FILING DATE: December 8, 1997

DOCKET NO: 392.1530/JDH:mbs

DUE DATE: February 5, 2003

ıse Date Stamp and return

, Form PTO 1449 & Copies of JP 06-268289, JP 07-099358, JP 04-259275 and English translation, FEE

PLICANT(S): Nobuaki IEHISA, et al.

RIAL NO: 08/973,424

NFIRMATION NO.

LE: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

NG DATE: December 8, 1997

CKET NO: 392.1530/JDH:mbs

E DATE: February 5, 2003

13

Docket No. 392.1530/JDH

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE 08/973424

In re Patent Application of:

PT18 Rec'd PCT/PTO 11 AUG 2003

Nobuaki IEHISA, et al.

Group Art Unit: To Be Assigned

Serial No.: To Be Assigned

Examiner: To Be Assigned

Filed: December 8, 1997

For: SLAB TYPE SOLID-STATE LASER OSCILLATING DEVICE

INFORMATION DISCLOSURE STATEMENT

Honorable Commissioner of
Patents & Trademarks
Washington, D.C. 20231

Sir:

In accordance with the duty of disclosure provisions of 37 C.F.R. §1.56, there is hereby provided certain information which the Examiner may consider material to the examination of the subject U.S. patent application. It is requested that the Examiner make this information of record if it is deemed material to the examination of the application.

1. Enclosures accompanying this Information Disclosure Statement are:

   1a. [X] Form PTO-1449.

   1b. [X] Copies of publications.

   1c. [X] An English language copy of search report(s) from a counterpart foreign application or PCT International Search Report.

   1d. [ ] Explanations of relevancy (ATTACHMENT 1(d), hereto) or English language abstracts of the non-English language publications.

   1e. [ ] List of Copending Applications (ATTACHMENT 1(e), hereto).

2. [X] This Information Disclosure Statement is filed under 37 C.F.R. §1.97(b) before the latter of three months after the U.S. patent application filing date or the first Office Action on the merits. Accordingly, no fee or certification is required.

3. [ ] This Information Disclosure Statement is filed under 37 C.F.R. §1.97(c) after the first Office Action on the merits, but before a Final Office Action or a Notice of Allowance.

(Check either Item 3a or 3b)

   3a. [ ] The Certification Statement in Item 5 below is applicable. Accordingly, no fee is required.

3b. [ ] The 0.00 fee set forth in 37 C.F.R. §1.17(p) accordance with 37 C.F.R. §1.97(c) is:
[ ] enclosed.
[ ] to be charged to Staas & Halsey Deposit Account No. 19-3935.

(Item 3b to be checked if any reference known for more than 3 months)

4. [ ] This Information Disclosure Statement is filed under 37 C.F.R. §1.97(d) after Final Office Action or Notice of Allowance, but before payment of Issue Fee.

4a. [ ] The Certification Statement in Item 5 below is applicable. Accordingly, no fee is required.

4b. A Petition to the Commissioner is hereby made under 37 C.F.R. §1.97(d) to request consideration of this Information Disclosure Statement. The $130.00 fee set forth in 37 C.F.R. §1.17(i)(1) is:
[ ] enclosed.
[ ] to be charged to Staas & Halsey Deposit Account No. 19-3935.

The Certification Statement in Item 5 below is applicable.

5. [ ] Certification Statement *(applicable if Item 3a or Item 4 is checked)*

(Check either Item 5a or 5b)

5a. [ ] In accordance with 37 C.F.R. §1.97(e)(1), it is certified that each item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application not more than three months prior to the filing of this Information Disclosure Statement.

5b. [ ] In accordance with 37 C.F.R. §1.97(e)(2), it is certified that no item of information contained in this Information Disclosure Statement was cited in a communication from a foreign patent office in a counterpart foreign application or, to the knowledge of the undersigned after making reasonable inquiry, was known by any individual designated in 37 C.F.R. §1.56(c) more than three months prior to the filing of this Information Disclosure Statement.

6. [ ] A continuation application under 37 C.F.R. §1.60 or §1.62 is concurrently filed herewith.

(Check appropriate Items 6a, 6b and/or 6c)

6a. [ ] A Petition to Withdraw from issue under 37 C.F.R. §1.313(b)(5) is concurrently filed herewith. A continuation application under 37 C.F.R. §1.62 after payment of the issue fee is proper in accordance with the U.S. Patent & Trademark Office's authorization in the Federal Register, Vol. 57, No. 12, January 17, 1992, at page 2032 (Reply to Comment 82).

6b. [ ] Copies of the publications listed on Form PTO-1449 from prior application Serial No. _____, filed on _____, of which this application claims priority under 35 U.S.C. §120, have been omitted pursuant to 37 C.F.R. §1.98(d).

6c. [ ] Copies of the publications listed on Form PTO-1449 which were not previously cited in prior application Serial No. _____, filed on _____, of which this application claims priority under 35 U.S.C. §120, are provided herewith.

7. [ ] This is a Supplemental Information Disclosure Statement. (*Check either Item 7a or 7b*)

08/973424

RECEIVED
TC 1700
11 AUG 2003

7a. [ ] This Supplemental Information Disclosure Statement under 37 C.F.R. §1.97(f) supplements the Information Disclosure Statement filed on _____. A bona fide attempt was made to comply with 37 C.F.R. §1.98, but inadvertent omissions were made. These omissions have been corrected herein. Accordingly, additional time is requested so that this Supplemental Information Disclosure Statement can be considered as if properly filed on _____.

7b. [ ] This Supplemental Information Disclosure Statement is timely filed within one (1) month of the U.S. Patent & Trademark Office _____ Notice under 37 C.F.R. §1.97(i).

8. [X] In accordance with 37 C.F.R. §1.98, a concise explanation of what is presently understood to be the relevance of each non-English language publication is:

(*Check Item 8a, 8b or 8c*)

8a. [X] satisfied because all non-English language publications were cited on the enclosed English language copy of the PCT International Search Report or the search report from a counterpart foreign application indicating the degree of relevance found by the foreign office. See U.S. Patent & Trademark Office's authorization in the Federal Register, Vol. 57, No. 12, January 17, 1992, at page 2031 (Reply to Comment 68).

8b. [ ] set forth in the application.

8c. [ ] enclosed as an attachment hereto.

9. The Commissioner is authorized to charge any additional fee required or credit any overpayment for this Information Disclosure Statement and/or Petition to Staas & Halsey Deposit Account No. 19-3935.

10. No admission is made that the information cited in this Statement is, or is considered to be, material to patentability nor a representation that a search has been made (other than a search report of a foreign counterpart application or PCT International Search Report if submitted herewith). 37 C.F.R. §§ 1.97(g) and (h).

Respectfully submitted,

STAAS & HALSEY

By: _____

James D. Halsey, Jr.
Registration No. 22,729

700 Eleventh Street, N.W.
Suite 500
Washington, D.C. 20001
(202) 434-1500
Date: March 31, 1999

FORM PTO-1449	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTY. DOCKET NO. 392.1530/JDH	SERIAL NO. To Be Assigned
LIST OF REFERENCES CITED BY APPLICANT		APPLICANT Nobuaki IEHISA, et al.	
(Use several sheets if necessary)		FILING DATE December 8, 1997	GROUP To Be Assigned

U.S. PATENT DOCUMENTS

*EXAMINER INITIAL		DOCUMENT NO.	DATE	NAME	CLASS	SUB-CLASS	FILING DATE
	AA	3,798,571	3/19/74	Segre			
	AB						

FOREIGN PATENT DOCUMENTS

		DOCUMENT NO.	DATE	COUNTRY	CLASS	SUB-CLASS	TRANSLATION YES	TRANSLATION NO
	AC	3-66185	03/20/91	Japan			abst.	
	AD							
	AE							
	AF							
	AG							
	AH							
	AI							
	AJ							
	AK							
	AL							

OTHER REFERENCES *(Including Author, Title, Date, Pertinent Pages, Etc.)*

	AM	
	AN	

EXAMINER	DATE CONSIDERED

*EXAMINER: Initial if reference considered, whether or not citation is in conformance with MPEP 609; Draw line through citation if not in conformance and not considered. Include copy of this form with next communication to applicant.

United States Patent [19]

Segre

[11] 3,798,571

[45] Mar. 19, 1974

[54] SLAB LASER SYSTEM WITH MEANS TO OVERCOME THE POSITIVE LENS EFFECT CAUSED BY THE THERMAL GRADIENT IN THE LASER ROD

[75] Inventor: Joseph P. Segre, Acton, Mass.

[73] Assignee: American Optical Corporation, Southbridge, Mass.

[22] Filed: June 9, 1969

[21] Appl. No.: 831,657

[52] U.S. Cl. ..... 331/94.5 T

[51] Int. Cl. H01s 3/05

[58] Field of Search ..... 331/94.5, 94.5 T

[56] References Cited

UNITED STATES PATENTS

3,484,714 12/1969 Koester et al. 331/94.5

Primary Examiner—Ronald L. Wibert

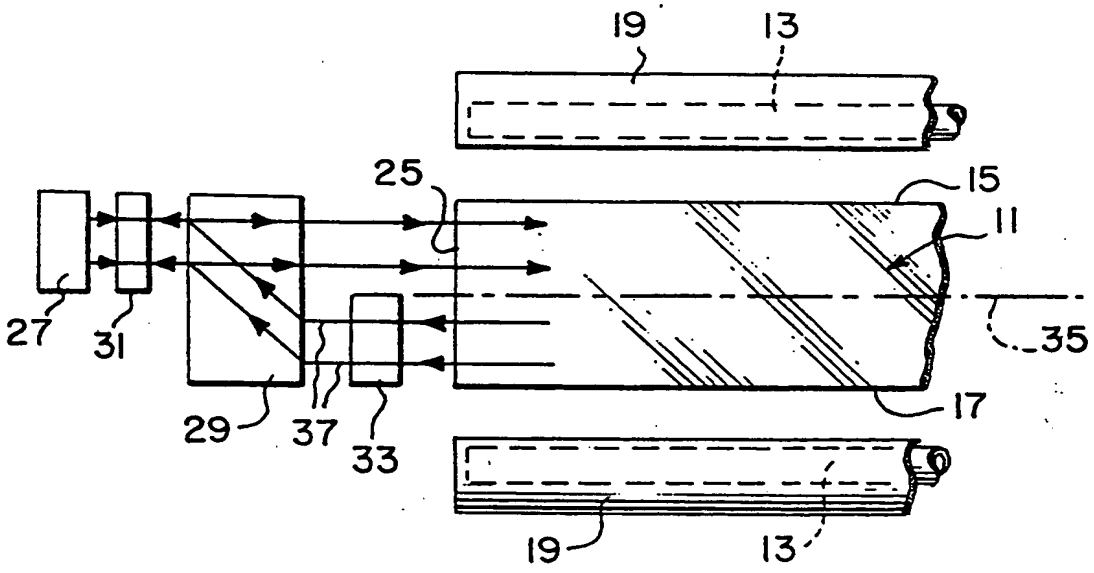
Assistant Examiner—V. P. McGraw

Attorney, Agent, or Firm—William C. Nealon

[57] ABSTRACT

In a glass laser system, the laser glass is in the shape of an elongated slab, which is excited by being irradiated through the larger sidewalls thereof. A calcite block plate in combination with quarter and half wave plates laterally shift the laser rays in the laser cavity to compensate for a positive lens effect caused by one dimensional thermal gradient in the laser glass. The calcite block and quarter and half wave plates also function to polarize the laser rays to have their E vectors parallel with the larger sidewalls of the slab.

14 Claims, 2 Drawing Figures



SLAB LASER SYSTEM WITH MEANS TO OVERCOME THE POSITIVE LENS EFFECT CAUSED BY THE THERMAL GRADIENT IN THE LASER ROD

BACKGROUND OF THE INVENTION

This invention relates to glass laser systems and, more particularly, to a glass laser system with means to overcome the positive lens effect which arises from the thermal gradient in the laser rod.

A conventional laser is excited to a state in which it will amplify light by periodically or continuously illuminating the rod with high intensity flashlamps. This excitation process is called pumping and the light which excites the laser material is called pump light. The light which the laser material amplifies is called laser light.

The pumping of a glass laser rod introduces heat into the rod approximately uniformly per unit volume throughout the rod. Yet heat is extracted from the rod only from the surface of the rod. As a result, in a round glass laser rod of the conventional configuration having an external length much longer than its diameter, a radial thermal gradient is built up. The radial thermal gradient results in a radial gradient in the index of refraction within the laser rod with the index being higher at the center of the rod than it is at the surface of the rod. As a result, the rod acts as a positive lens upon the laser beam and operates to focus on the laser beam in the center of the laser rod.

The focusing of the laser beam by the laser rod is undesirable because the volume in which the laser action takes place is reduced thus reducing the efficiency of the rod. Moreover, the spread of the laser beam produced by the rod is increased. In most laser applications, minimum beam spread is desired at the target receiving the laser beam in order to deliver maximum energy to the target. In addition, because of the positive lens action of the laser rod, the laser beam can collapse into a destructive filament as a result of self-focusing of the laser beam. Self-focusing of a laser beam causing the laser beam to collapse into a destructive filament occurs because the index of refraction in material, in general, is increased by the high intensity electric field present in the laser beam. The intensity of a laser beam is usually highest in the center and varies with a gaussian distribution from the center outwardly. As a result, the index of refraction in general will be higher at the center of the medium through which the beam is passing than it will at the edge. If the increase in the index of refraction with the electric field in the laser beam is high enough, the beam will collapse due to the resulting dynamic positive lensing effect into a diffraction limited filament. At this point, the power density in the laser beam will exceed the damage threshold of the material and a fine fossil record is left where the laser beam passes through the material. The self-focusing resulting in the laser beam collapse will occur at a much lower threshold when even a small amount of positive lens power is initially present in the material. Thus, the presence of the thermal radial gradient will lower the threshold at which this beam collapse occurs.

In the glass lasers of the prior art, a number of approaches have been employed to overcome the problem of thermal lensing such as introducing into the cavity negative lenses to counteract the positive lens effect

of the thermal gradient. This method of compensation has the disadvantage that it compensates for only one set of operating conditions. A zoom telescope could be used in the laser cavity to counteract the effects of thermal lensing but the telescope requires continuous resetting as the operating conditions change.

SUMMARY OF THE INVENTION

The present invention provides an entirely different approach to the problem of thermal lensing. In accordance with the present invention, the laser glass instead of being in the shape of a round rod is in the form of an oblong slab which is pumped by means of flashlamps located opposite the larger sidewalls of the slab. As a result, the thermal gradient which is produced in the laser glass of the slab is approximately one dimensional in that it approaches the condition of having the locus of the maximum temperature in a plane parallel to the larger sidewalls of the slab passing through the middle of the slab. The temperature gradient decreases from the high temperature plane toward the larger sidewalls of the slab. As a result, the slab acts like a positive cylindrical lens tending to focus the laser light toward the high temperature plane in the middle of the slab. In accordance with the present invention, means are provided to cause the laser rays to pass alternately through opposite sides of the slab in a manner so that the rays near the central high temperature plane in one side of the slab are near the large sidewall in the other side of the slab and vice versa. As a result, each ray passes through material of a relatively high index of refraction in one side of the slab and through material of a relatively low index of refraction in the other side of the slab and in this manner the lens power of the slab is cancelled out.

In a slab laser, the minimum beam divergence is achieved for laser rays polarized so that their electric field vectors are parallel to the larger sidewalls of the slab. The ray transferring means also operates to transfer rays which do not have such polarization out of the cavity. Thus, the system of the present invention also reduces beam divergence in a slab laser system.

Accordingly, an object of the present invention is to provide an improved glass laser system.

Another object of the present invention is to overcome the problem of thermal lensing in a glass laser system.

A further object of the present invention is to provide a laser system in which the problem of thermal lensing is overcome.

A still further object of the present invention is to overcome the one dimensional thermal gradient that is produced in a slab type laser system.

A further object of the present invention is to minimize beam divergence in a slab laser system.

Further objects and advantages of the invention will become readily apparent as the following description of a preferred embodiment unfolds and when taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic perspective view of the laser system of the present invention; and,

FIG. 2 is an enlarged plan view of a portion of the system shown in FIG. 1.

the desired polarization in the slab 11 will be present. Thus, the calcite plate 29 functions as a polarizer to limit the laser oscillation to those which provide minimum beam divergence.

Because the rays are laterally transferred by the calcite plate 29, the rays which are near the sidewall of the slab on one side of the slab will be near the center of the slab when travelling through the slab on the other side of the slab. Moreover, since each ray is laterally transferred by an amount equal to one half the slab width, the distance that each ray is from the sidewall on one side of the slab will be equal to the distance that this ray is from the center plane 35 on the other side of the slab.

The flashlamps 19 in addition to exciting the laser material of the slab 11 also introduces heat into the slab 11 substantially uniformly per unit volume of the slab. Heat, however, is removed from the slab only through the surfaces of the slab. Since the larger surfaces are the surfaces 15 and 17, most of the heat is removed from the slab through these surfaces. This condition results in a thermal gradient being built up in the slab 11 which is approximately one dimensional perpendicular to the plane 35 with the locus of higher temperature being at the plane 35. The index of refraction of the laser glass varies with the temperature, with the highest index of refraction being where the temperature is highest and the lowest index of refraction being where the temperature is lowest. Thus, the one dimensional thermal gradient in the slab 11 will cause a one dimensional gradient in tne index of refraction of the slab 11 with the longest optical path being on the center plane 35 and the shortest optical paths being near the sidewalls 15 and 17. This gradient in the index of refraction will make the slab 11 act as a cylindrical lens tending to focus the laser light energy on the plane 35. However, because of the lateral shifting of the rays with the desired polarization provided by the calcite plate 29, whereby the rays which are near the sidewall of the slab 11 when passing through one side of the slab pass through the other side of the slab near the center of the slab and vice versa, all of the rays will travel substantially the same optical distance in the slab 11 after passing through both sides of the slab. Accordingly, the cylindrical lens effect of the slab for these rays is cancelled out. Thus, the problem of thermal lensing is overcome by using a laser rod in the form of a slab to achieve a cylindrical lensing effect and by using the calcite plate and the quarter and half wave plates to laterally shift the rays.

The above description is of a preferred embodiment of the invention and many modifications may be made thereof without departing from the spirit and scope of the invention which is defined in the appended claims.

I claim:

1. A laser system comprising an elongated slab of laser material having an axis of symmetry extending parallel to the longitudinal dimensions thereof, means to irradiate said slab with pump light through the larger sidewalls thereof, a reflector positioned opposite one end face of said slab to reflect laser rays travelling through said slab parallel to said axis back into said slab, and ray shifting means positioned opposite the other end face of said slab to reflect laser rays travelling through said slab parallel to said axis back into said slab and to shift the rays which are near the center of said slab to be near the sidewalls of said slab and vice versa.

2. A laser system as recited in claim 1 wherein said ray shifting means shifts each ray so that after being shifted such ray is the same distance from a larger sidewall of said slab that such ray prior to being shifted was from a center plane passing through the middle of said slab parallel to said larger sidewalls.

3. A laser system as recited in claim 1 wherein said ray shifting means shifts the rays from one side of said slab to the other, said sides of said slab being divided by a center plane passing through the middle of said slab parallel to said larger sidewalls.

4. A laser system as recited in claim 3 wherein said ray shifting means comprises a second reflector facing said other end face of said slab, a calcite plate between said reflector and said slab oriented to laterally shift rays which are polarized so that their E vectors are perpendicular to said center plane, first polarization rotating means to rotate 90° the polarization of laser rays travelling parallel to said axis between said center plane and the plane of one of said larger sidewalls as such laser rays travel between said calcite plate and said other end face of said slab, and second polarization rotating means to rotate 90° the polarization of lazer rays travelling parallel to said axis between said center plane and the plane of the other sidewall of said slab as such rays travel from said calcite plate to said second reflector and back.

5. A laser system as recited in claim 4 wherein said calcite plate laterally shifts the rays by an amount equal to half the thickness of said slab.

6. A laser system as recited in claim 4 wherein said first polarization rotating means comprises a half wave plate positioned between said calcite plate and said other end face of said slab and extending only from said center plane to the plane of one of said sidewalls, and wherein said second polarization rotating means comprises a quarter wave plate positioned between said calcite plate and said second reflector.

7. A laser system as recited in claim 4 wherein said second reflector is parallel to said end face and is coextensive only with the half of said end face between said center plane and the plane of said other sidewall.

8. A laser system as recited in claim 1 wherein said laser material is laser glass.

9. A laser system as recited in claim 1 including means to polarize the laser oscillations generated by said system to have their E vectors to be parallel to said larger sidewalls.

10. A laser system comprising an elongated block of laser material having an axis of symmetry extending parallel to the longitudinal dimension thereof, means to pump said laser material in a manner to generate an approximately one dimensional thermal gradient in said block with the locus of high temperature being on a plane passing through the middle of said block parallel to a pair of sidewalls of said block, a reflector positioned opposite an end face of said block to reflect laser rays travelling through said block parallel to said axis back into said block, and ray shifting means opposite the other end face of said block to reflect the rays travelling through said block parallel to said axis back into said block and to laterally shift the rays near said center plane to be near said sidewalls and vice versa.

European Patent Office

SUPPLEMENTARY EUROPEAN SEARCH REPORT

Application Number
EP 97 91 4629

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.6)
A	PATENT ABSTRACTS OF JAPAN vol. 015, no. 229 (E-1076), 11 June 1991 -& JP 03 066185 A (TOSHIBA CORP), 20 March 1991 * abstract; figure 3 *	1-10	H01S3/06 H01S3/081
A	US 3 798 571 A (SEGRE J) 19 March 1974 * abstract * * column 2, line 9 - line 61 *	1-10	

TECHNICAL FIELDS SEARCHED (Int.Cl.6)

H01S

The supplementary search report has been based on the last set of claims valid and available at the start of the search.

Place of search	Date of completion of the search	Examiner
THE HAGUE	15 October 1998	Iasevoli, R

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C04)

1

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 97 91 4629

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

15-10-1998

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 3798571 A	19-03-1974	NONE	

Patent Abstracts of Japan

PUBLICATION NUMBER : 03066185
PUBLICATION DATE : 20-03-91

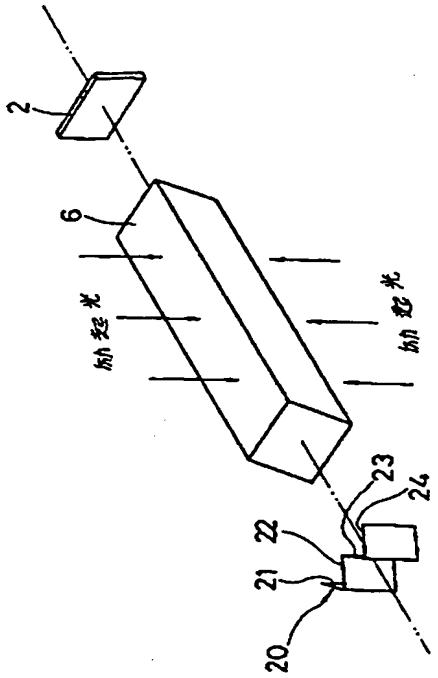
APPLICATION DATE : 04-08-89
APPLICATION NUMBER : 01202325

APPLICANT : TOSHIBA CORP;

INVENTOR : YAMADA AKITAKA;

INT.CL. : H01S 3/08

TITLE : SLAB TYPE LASER OSCILLATOR



ABSTRACT : PURPOSE: To equalize the effect of temperature distribution exerted on the thickness of a slab laser medium and its lateral direction by allowing a high reflection optical system to have a rectangular bending reflecting interface, a crest-shaped top to locate on an optical axis, and a bending section to cross in a lateral direction of the slab layer medium.

CONSTITUTION: A high reflection mirror 20 and an output mirror 2 constitute an optical oscillator and a slab laser medium 6 is installed on an optical axis. The high reflection mirror 20 comprises four flat plane mirrors 21, 22, 23, and 24, which are arranged in a W shape with an angle of 90°. The central position of the letter W is identical to the optical axis of the optical oscillator. When it is observed as the lateral direction of the slab laser medium 6 is observed, they are arranged to form the letter W. The plane mirrors 21, 22, 23, and 24 are a high reflection surface formed with a dielectric multi-layer film. The laser light travels back and forth between the output mirror 2 and the high reflection mirror 20 several times and output as a laser light 21. This construction makes it possible to correct the optical path difference produced by differential index of refraction or expansion induced by the effect of heat lens and further equalize the temperature distribution and minimize the effect of heat lens.

⑲日本国特許庁(JP)　⑪特許出願公開

⑫公開特許公報(A)　平3−66185

⑤Int.Cl.[5]　識別記号　庁内整理番号　⑬公開　平成3年(1991)3月20日

H 01 S　3/08

6940−5F　H 01 S　3/08　Z

審査請求　未請求　請求項の数 1　(全6頁)

⑭発明の名称　スラブ型レーザ発振装置

⑳特　願　平1−202325

㉒出　願　平1(1989)8月4日

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明　細　書

1．発明の名称

スラブ型レーザ発振装置

2．特許請求の範囲

断面が矩形に形成されかつ長手方向の両端部にそれぞれ厚さ方向に対して所定角度の傾斜面が形成されたスラブレーザ媒質と、このスラブレーザ媒質を励起する励起手段と、前記傾斜面の一方に対面して配置された出力光学系と、前記傾斜面の他方に対面して配置されて前記出力光学系とともに光共振器を構成する高反射光学系とを備えたスラブ型レーザ発振装置において、前記高反射光学系は一対のほぼ直角の屈曲反射面を有し、前記一対の屈曲反射面で作る山状の頂部が前記光共振器の光軸上に位置しかつ前記光共振器の光軸を中心にして2等分した各領域に前記屈曲反射面の屈曲部が前記領域の中心線上に位置するとともに前記屈曲部が前記スラブレーザ媒質の幅方向に直交するようにして前記屈曲反射面を対面させたことを特徴とするスラブ型レーザ発振装置。

3．発明の詳細な説明

〔発明の目的〕

(産業上の利用分野)

本発明はスラブ型レーザ発振装置に関する。

(従来の技術)

第4図はYAGレーザなどの固体レーザ発振装置の構成図であって、かかる装置はロッド形状に形成された固体レーザ媒質1を光共振器を構成する出力ミラー2と反射ミラー3との光軸上に配置し、かつ固体レーザ媒質1の側面側にKrアークランプやXeフラッシュランプなどの励起用光源4，4を配置した構成となっている。又、固体レーザ媒質1には熱が生じることから、この固体レーザ媒質1の周囲には冷却水が流されている。このような構成により励起用光源4，4により固体レーザ媒質1が光励起されると、出力ミラー2と反射ミラー3との間で光共振が生じて出力ミラー2からレーザ光5が出力される。

ところが、このようなレーザ発振装置では固体レーザ媒質1に熱が生じ、この熱の温度分布はほ

（実施例）

以下、本発明の一実施例について図面を参照して説明する。なお、第５図と同一部分には同一符号を付してその詳しい説明は省略する。

第１図はスラブ型レーザ発振装置の構成図であり、第２図は外観図である。同図において２０は高反射ミラーであって、この高反射ミラー２０は出力ミラー２とともに光共振器を構成している。そして、この光共振器の光軸にスラブレーザ媒質６が配置されている。高反射ミラー２０は、一対のほぼ直角の凹曲反射面を有し、これら一対の凹曲反射面で作る山状の頂部が光共振器の光軸上に位置しかつ光共振器の光軸を中心にして２等分した各領域に凹曲反射面の凹曲部がそれぞれ領域の中心線上に位置するとともに凹曲部がスラブレーザ媒質６の幅方向に直交するようにして凹曲反射面を対面させた構成のもので、具体的には、４面の平面ミラー２１，２２，２３，２４を２枚１組例えば平面ミラー２１と２２、２３と２４によりほぼ直角な各凹曲反射面を形成している。つまり

４面の平面ミラー２１，２２，２３，２４をＷ字状にそれぞれ90°の角度をもって配置した構成となっている。そして、この高反射ミラー２０はＷ字の中間位置と光共振器の光軸とが一致しかつスラブレーザ媒質６の幅方向を見る方向から見た場合にＷ字となるように配置されている。なお、各平面ミラー２１，２２，２３，２４は誘電体多層膜で形成される高反射面となっている。

次に上記の如く構成された装置の作用について説明する。

スラブレーザ媒質６が各励起光源４，４により光励起されると、レーザはスラブレーザ媒質６内の厚さ方向で反射しながら伝播する。そして、出力ミラー２と反射ミラー３との間で複数回往復してレーザ光２１として出力されるが、このときレーザは光共振器の光軸を中心に分けたスラブレーザ媒質６の幅方向の各領域においてそれぞれ反転される。すなわち、第３図を参照して光共振器の光軸ｓで分けられた一方の領域について説明すると、例えば経路ａでスラブレーザ媒質６から出力

されたレーザは平面ミラー２２，２１で反射して経路ｂを通ってスラブレーザ媒質６に入り、又経路ｃでスラブレーザ媒質６から出力されたレーザは平面ミラー２２，２１で反射して経路ｄを通ってスラブレーザ媒質６に入る。これにより、温度分布ｅ１を通るレーザは温度分布ｅ２を通るレーザと重なり、又温度分布ｅ３を通るレーザは温度分布ｅ４を通るレーザと重なる。しかるに、スラブレーザ媒質６の幅方向の温度分布Ｑは高反射ミラー２０により光軸ｓで分けられた各領域において反転して温度分布Ｑ´となる。しかるに、これら温度分布ＱとＱ´とが重なり合って温度分布は均一化される。

このようにしてレーザは出力ミラー２と高反射ミラー２０との間で複数回往復してレーザ光２１として出力される。

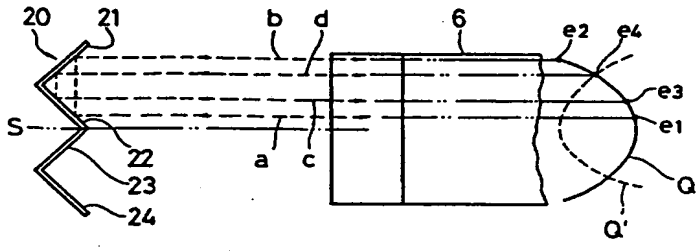
このように上記一実施例においては、スラブレーザ媒質６内をレーザは反射しながら伝播するとともに光共振器を構成する出力ミラー２と高反射ミラー２０との間で高反射ミラー２０により光共

振器の光軸を中心にスラブレーザ媒質６の幅方向に対して２領域に分けられてそれぞれの領域において反転されて伝播するので、熱レンズ効果が原因による屈折率差や影響などで生じる光路差を補正でき、スラブレーザ媒質６の厚さ方向における温度分布が均一化できるとともに幅方向の温度分布が均一化できて熱レンズ効果を非常に小さくできる。これにより、スラブレーザ媒質６の幅方向におけるレーザ光２１の広がり角を15mrad程度から５mrad程度に狭くできる。又、第３図に示すようにレーザが例えばスラブレーザ媒質６の中央部と端部とを交互に通過するので、利得が平均化されてマルチモードなどでは中央部がマーキングに適した比較的平坦なレーザ光が得られる。

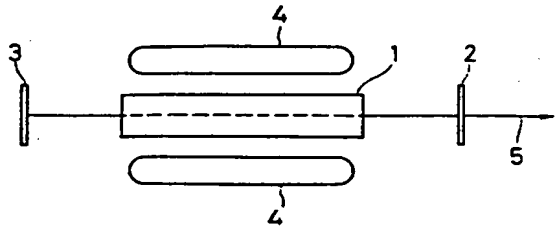
なお、本発明は上記一実施例に限定されるものでなくその主旨を逸脱しない範囲で変形しても良い。例えば、高反射ミラー２０は直角三角状のプリズムを組み合わせた構成としても良い。

［発明の効果］

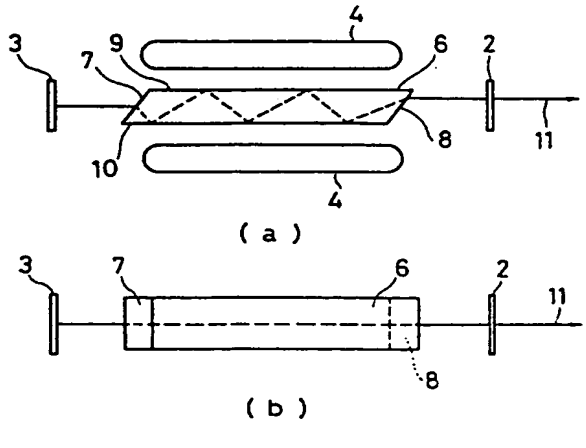
以上詳記したように本発明によれば、厚み方


20
21
b
d
6
e2
e4
e3
e1
S
22
23
24
a
c
Q
Q'

第 3 図


4
3
1
2
5
4

第 4 図


4
3
9
7
6
2
8
11
10
4
(a)
3
7
6
2
11
Q
8
幅方向
(b)

第 5 図

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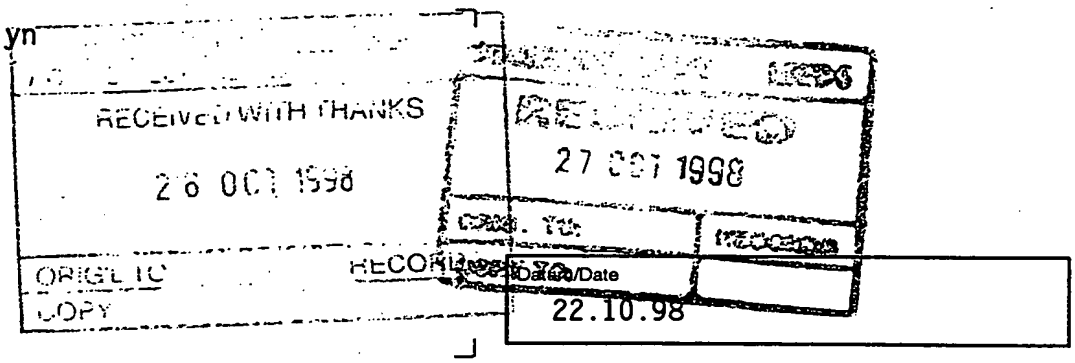

Zeichen/Ref./Réf.	Anmeldung Nr./Application No./Demande n°./Patent Nr./Patent No./Brevet n°.
LEB/HL58514	97914629.7-2214-JP9701195

Anmelder/Applicant/Demandeur/Patentinhaber/Proprietor/Titulaire
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COMMUNICATION

The European Patent Office herewith transmits as an enclosure the European search report for the above-mentioned European patent application.

If applicable, copies of the documents cited in the European search report are attached.

☐ Additional set(s) of copies of the documents cited in the European search report is (are) enclosed as well.

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